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Short- and long-run associations between birth weight and children's height

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ABSTRACT

Much evidence suggests that the 1000 days spanning from conception to children's second birthdays are critical for physical development. Whether influence of the exposures occurring during this window lasts later in life is unclear. Our study investigates changes in associations between birth weight and height, one measure of physical development, over different life-stages and whether greater household wealth promotes better growth for low birth weight (LBW) children. Using longitudinal data from Young Lives, we analyzed associations between birth weight and physical growth and examined differences across ages and by household wealth for 3999 children from Ethiopia, India, Peru, and Vietnam. At 6–18 months, LBW children had 0.53-SD (Standard error [SE]: 0.08) lower HAZ. Over time, the gap between normal and LBW children narrowed significantly to 0.21-SD (SE: 0.05) and 0.24-SD (SE: 0.05) at 4–5 years and 7–8 years, respectively. Prenatal experiences are most salient in establishing the greatest height deficits within the first year. Although disparities in height are reduced in the first year, height differences at age 4–5 years remain at 7–8 years of age. Even among wealthier families, there was no recovery in height for LBW children during the first year and no catch-up growth for these children in later childhood. These findings suggest that prenatal conditions, reflected in birth weight, are more important in setting height trajectories in comparison to postnatal factors, which do not help children recover fully from early growth deficits.

1. Introduction

Over 161 million children suffer from stunting or low height for age that reflects sustained experiences of undernutrition (UNICEF, 2015). Stunting begins early during a critical window spanning the first 1000 days of life (Victora et al., 2010). Children born at low birth weight, a measure of poor fetal conditions (Kramer, 1987), are more likely to be stunted or more generally experience worse physical growth (Christian, 2014; Christian, 2009; Christian et al., 2013). The large burden of low birth weight and stunting in low- and middle-income countries (UNICEF, 2015; WHO and UNICEF, 2004) and the grave consequences of poor developmental outcomes across the life-course (Black et al., 2013) create an imperative for understanding the relationships between poor fetal health

Abbreviations: BWI, baseline wealth index; HAZ, height for age *z*-score; IUGR, intrauterine growth restriction; LBW, low birth weight; SD, standard deviation; SE, standard error; WHO, World Health Organization.

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and postnatal growth in order to improve child health and development.

Using a uniquely rich longitudinal data set from four low-and middle-income countries, our study investigates whether birth weight, a measure of prenatal experiences, influences postnatal growth and compares the relative contributions of prenatal and postnatal factors to height. In addition, we compare associations across four countries with different social, economic, and political contexts. We also explore how household socioeconomic status influences the relationship between birth weight, height, and catch-up growth.

Previous studies have examined the relationship between birth weight and physical development. Cross-sectional (Adekanmbi et al., 2013; Bove et al., 2012; Gewa and Yandell, 2012; Jesmin et al., 2011; Massad et al., 2012; Varela-Silva et al., 2009) and longitudinal studies (Araujo et al., 2008; Christian et al., 2013; Tome et al., 2007) demonstrate that children who were born at low birth weight are either more likely to be stunted or experience deficits in height at various ages; however these studies, examining associations at only one point in time, are unable to investigate how postnatal factors may affect the relationship between birth weight and postnatal growth. Few studies explore the lasting effects of birth weight on children's growth over time with some finding that there is limited catch-up growth in low birth weight children (Das et al., 2012; Schmidt et al., 2002) while others conclude that height deficits are unlikely to be remediated (Arifeen et al., 2000; Sania et al., 2014). The paucity of research on the long-term effects of birth weight and the mixed evidence from small, country-level studies suggests that further research needs to investigate whether the relationship between birth weight and physical growth exists only early in life or whether it persists over the life course.

2. Conceptual relationships between prenatal and postnatal factors and child height

Low birth weight (LBW), defined as having a birth weight of less than 2500 g, is one measure of poor fetal health (WHO and UNICEF, 2004). There is higher infant mortality among those born at LBW (Katz et al., 2013), and for those who survive, there is a higher burden of morbidity including poor developmental outcomes (WHO and UNICEF, 2004). In terms of physical development, birth weight marks the beginning of a cumulative process of growth faltering (United Nations Sub-Committee on Nutrition, 1997) with higher stunting rates among children born at low birth weights (Christian et al., 2013). In low-and middle-income countries, LBW is primarily caused by intrauterine growth restriction (rather than preterm birth, which is the other proximate determinant) (Kramer, 1987; Lee et al., 2013), and intrauterine growth restriction (IUGR) has a stronger association with stunting than preterm birth (Christian et al., 2013). IUGR is influenced by short maternal stature, low pre-pregnancy weight, poor gestational nutrition, and infections and inflammation (due to diseases such as malaria) (Kramer, 1987) and more distally through a multitude of socioeconomic conditions such as poverty, educational attainment, employment conditions, and lack of access to health services (Kramer, 1998; Valero de Bernabé et al., 2004). Together, these factors leading to poor fetal conditions are linked to higher risk of stunting.

Postnatal factors such as social and economic conditions also influence child height with higher rates of stunting among poor families with low levels of educational attainment (Black et al., 2013). There are a variety of pathways through which poverty influences stunting (Black et al., 2013). First, households that are poor are able to provide lower quantities and qualities of food to their children. Second, there are higher rates of infection and disease in poorer households that contribute to poor physical development. Worse water quality and sanitary conditions within poor households also add to the higher burden of disease. Third, psychosocial aspects such as higher maternal stress and lower quality care also influence child development.

How these prenatal and postnatal factors interact to influence child development is a key concern. Although 20% of global burden of stunting can be attributed to impaired fetal growth (Black et al., 2013), there is also evidence that postnatal conditions matter for children's physical development (Black et al., 2013). Our study attempts to shed further light into whether prenatal or postnatal factors matter more for child height and which set of determinants matters more later growth. One way to examine whether the relationship between birth weight and child height is biologically determined is to explore whether the relationship between birth weight and child height varies using harmonized data from cohorts in four diverse countries. Similar associations in these different contexts would suggest that poor fetal conditions affect all children equally, implying that there may be some biological link between birth weight and height. Indeed, a recent meta-analysis found little variability in the associations between birth outcomes and children's physical development (Christian et al., 2013). Conversely, differences in associations, particularly between birth weight and later growth, would suggest that varying postnatal circumstances may help (or harm) children in some of these contexts. The longitudinal nature of our study, which considers physical development cross-nationally, permits an investigation into the varying associations between birth weight and height over time and between different contexts.

3. Methods

3.1. Study population

This study used data from Young Lives, a longitudinal study of child health and well-being in Ethiopia, India, Peru, and Vietnam (Barnett et al., 2013). Young Lives was designed to follow two cohorts: a younger cohort born in 2000–2001 and an older one born in 1994–1995. At baseline, the younger cohort was 6–18 months old while the older cohort was 7–8 years old. In subsequent follow-ups in 2006 and 2009, the younger cohort was 4–5 and 7–8 years old while older cohort was 11–12 and 14–15 years old (Barnett et al., 2013). We used only the younger